*The Journal of*

# THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

*Registered at the G.P.O., Sydney, for transmission by post as a periodical.*

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VOL. 2, No. 1 MARCH, 1936

## The Death of King George V

At the first meeting for this year of the Executive Committee of the Institute, the following resolution was moved from the Chair by the President, Professor A. E. V. Richardson, and carried unanimously:—

"The members of The Australian Institute of Agricultural Science desire to convey to His Excellency the Governor-General the profound grief which they feel at the passing of His Majesty King George V., and to express their loyalty to the throne and person of His Majesty King Edward VIII."

This resolution, the Honorary Secretary was directed to transmit to the Official Secretary to the Governor-General for submission to His Excellency.

# Editorial

## AGRICULTURAL EXTENSION

A noticeable feature of some of the addresses recently delivered at meetings of branches of the Institute was the reference to the importance of extension work in agricultural development. To state that farming has grown from a haphazard type of occupation into a business demanding training and skill is to state a truism with which everybody is familiar; but it would imply at the same time that facilities for extending information on latest developments to the farming public not only are available but are being utilised to good account —if not by all, then by the majority of primary producers. All this serves to emphasise the very important function the agricultural extension worker fulfils in our national progress.

During the past century all manner of improvements have been developed and put into practice with the result that the standard of agriculture to-day is on a high plane, and while the scientific investigator can point with pride to the development of fertilisers, improved crop varieties, new methods of pest and disease control and so forth, the important part played by those acting in the capacity of disseminators of information does not always receive full recognition. The very nature of extension work is slow in effect, and by comparison with the sudden and often epoch-making discoveries arising from scientific research, the results are not nearly so spectacular. This is probably one reason why the university-trained man not infrequently chooses in preference the experimental laboratory for his life's career. There is, too, a certain dignity and status attached to positions of a research nature and this, together with the trend of university training, doubtless partly explains why the number of graduate entrants into extension work is relatively small. Arising out of the developments for which scientific research is responsible, new problems continue to appear and these constitute a challenge to the technical worker. It is a matter for regret that persons quite unsuited for intensive investigational work frequently find their way into research laboratories when their peculiar personal qualifications and inclinations befit them more for effective service in other spheres of unquestioned importance.

Agricultural research can be of little value unless the ultimate result is to improve the position of the man on the land. For that reason the qualifications of an extension worker who acts in the capacity of an intermediary between the investigator and the farmer, require to be such that there is every guarantee that the benefits from research may be fully exploited by primary producers generally, and there is no doubt that the man with a good cultural background, a technical training and a full understanding of the farmer's viewpoint can best undertake the responsibilities in this connection. In addition to acting as

an interpreter to the farmer, the extension worker should also be in the happy position of being able to detect new problems requiring solution or the weaknesses in new developments resulting from experimental work, and thus should be of great assistance to the investigator.

While the importance of research can never be underestimated, statements are occasionally made to the effect that investigational work might well cease for a time to enable a stocktaking of the entire position as it now exists and to encourage a wider application of the knowledge already in hand. Only a few years ago, Sir George Julius in addressing a meeting of the A. & N.Z.A.A.S. in Sydney, emphasised the need for greater co-operation among scientists in making scientific material available to the people who wanted it, and stated: "They (the scientists) must try to educate the producer to a better use of the methods already available." The position to-day is much the same as when Sir George made these remarks in 1932: it is one concerning which there would be little difference of opinion, but if in extending and improving existing services graduates in agricultural science are to be attracted more so than in the past, then it will be necessary for increased status to be accorded to this type of work.

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# Entomological Research in Queensland

By

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The investigation of entomological problems occupies quite a prominent position in agricultural research programmes in the State of Queensland, and a brief survey of the early days of economic entomology in this State and of the present organisation of entomological research therein may be of interest to readers of this Journal.

As far back as 1875 a board was appointed for the purpose of conducting enquiries into diseases affecting crops and live stock, the board receiving an appropriation of £2,500 during the years 1875 to 1877. The board issued four reports, the second of which contained an account of an important insect enemy of sugar-cane in plantations on the Albert River. The author of this article was Dr. Joseph Bancroft who is accordingly entitled to the credit for having written one of the earliest, if not the earliest, articles on economic entomology in Queensland. Dr. Bancroft, of course, is well known as a pioneer in medical and general biological research in Queensland, his medical researches including valuable pioneering work in filaria.

The year 1889 is noteworthy for the appearance of a handbook entitled "Report on Insect and Fungus Pests No. 1." This comprehensive and valuable publication was issued by the Government, the text having been prepared by Mr. Henry Tryon, who was then associated with the Queensland Museum.

Mr. Tryon was subsequently appointed Entomologist to the Department of Agriculture and Stock in 1893, where he worked single handed with one brief interval until 1908, when a permanent assistant was appointed. Little increase took place in the Departmental entomological staff until 1923, but since then development has been rapid, and the staff now consists of sixteen officers, twelve of whom belong to the general entomological branch, three to the entomological section of the Bureau of Sugar Experiment Stations, and one to the State Animal Health Station at Yeerongpilly.

A policy of decentralisation has been pursued during recent years, and general entomological field stations are now in existence at Atherton, Rockhampton, Nambour and Stanthorpe, while the establishment of a fifth station at Toowoomba has been approved. The Bureau of Sugar Experiment Stations has two permanent field stations, one at Meringa and the other at Mackay, while as already mentioned the veterinary entomologist has his headquarters at Yeerongpilly in the suburbs of Brisbane.

## GENERAL ENTOMOLOGICAL BRANCH OF THE DEPARTMENT

The research programme carried out by the general entomological branch covers a wide field, for this branch is responsible for the investigation of all agricultural, horticultural and silvicultural entomological problems, with the single exception of those associated with the production of sugar-cane. Each field station has its own particular set of research projects, the main features of which are outlined in the following paragraphs.

The field station in North Queensland was originally established at Cairns eight years ago, the first major investigation undertaken at that centre being the problem of the control of banana thrips, an insect which has been responsible for a very high percentage of loss of fruit in banana plantations in Queensland. For various sound reasons the research work on banana thrips was transferred to Southern Queensland some years ago and this fact, together with the development of tobacco production on an extensive scale in the Cairns hinterland and the growing intensity of the white grub problem on the Atherton Tableland, led to the transfer of the northern field station from Cairns to Atherton three years ago. A number of projects have already been finalised by the staff of this station during the eight years of its existence, these including the investigation of the pin hole borer of North Queensland cabinet woods which was undertaken on behalf of the Forestry Sub-Department following the incidence of severe losses in valuable veneering timbers used locally in Australia, and shipped overseas mainly to furniture manufacturing centres in the United States of America. The investigation of the leaf miner and stem borer of tobacco, both most important problems in the new tobacco producing districts in this State, has also been finalised, while another important project brought to a successful conclusion was the study of important species of seed harvesting ants.

At the present moment the chief research project at this northern field station is the investigation of the very serious white grub problem associated with paspalum on the Atherton Tableland, where an area of 25,000 acres is suffering from very severe infestation.

The Rockhampton field station was established in 1934, the main research project at that centre being the study of cotton pests. Naturally the corn ear worm features prominently in such a programme for it is undoubtedly the most destructive insect associated with cotton. The problem of the control of this pest, however, is not confined to its incidence on cotton, for the corn ear worm is also being investigated as a major pest of tomato, tobacco, maize and lucerne.

The establishment of the Nambour field station took place in 1930, and for obvious reasons it has functioned mainly for the investigation of fruit pests, particular attention being devoted to the insect enemies of citrus. Here again a number of important projects have been satisfactorily finalised, work having ceased on the larger horned citrus bug, the bronze orange bug, and a wide range of scale insects, these species constituting the most important enemies of citrus in this State. Attention is now being devoted to other citrus problems such as the leaf-eating weevil and the citrus root bark channeller, while arrangements have been made for the initiation of work, as soon as practicable, on certain strawberry pests. The investigation of the banana thrips problem is also conducted at the Nambour station, and it is hoped that this particular project will be finalised late this year, the successful completion of the work being conditional on the incidence of a reasonably heavy infestation of thrips on suitable experimental plantations.

The Stanthorpe field station was actually the first to be established, having been opened in 1922. Its chief activity has been the study of problems of deciduous fruits, although a certain amount of attention has also been devoted to market garden pests. The Queensland fruit fly has been the subject of a great deal of investigation at that centre, not only by the Department of Agriculture and Stock, but also by a research fellow who was for a number of years associated with the University of Queensland. Very considerable progress has been made in this problem but, as is the case with fruit fly problems elsewhere, satisfactory finality has not yet been reached. The codling moth has also featured largely in the Stanthorpe research programme during recent years mainly on account of the desire to obtain a suitable non-arsenical spray for the control of this pest.

It is intended that the Toowoomba field station, when established, shall deal mainly with problems of general agriculture, and that particular attention shall be devoted to the insect pests of cereals, lucerne, sweet potato and pumpkin.

The research activities of the headquarters staff in Brisbane cover a wide field, as is frequently the case with a headquarters section of an organisation, but they deal mainly with market garden and general agricultural problems.

The insects at present claiming most attention from the Brisbane investigators are the green vegetable bug, which is rapidly becoming a major pest in this State, the grape vine mealy bug, the Rutherglen bug and the fig leaf beetle. Forest entomological problems are also receiving a considerable amount of attention, white grubs in coniferous plantations being the most important of the projects associated with the living tree. The notorious powder post beetle is also being investigated as a serious source of loss in forest products. An important headquarters project which has been successfully concluded is the study of the control of cabbage pests by the use of non-arsenical sprays.

Some attention has been given to the possibilities of the biological control method of attack and as has been the case in other countries, the different projects have met with a varying degree of success. The introduction of the apple woolly aphis parasite has been a decided success, whereas the attempt to control the codling moth by the mass breeding of an egg parasite appeared to be a complete failure. Two predatory enemies of the banana weevil borer were introduced from Java, but both failed to achieve permanent establishment. At present an Egyptian egg parasite of the green vegetable bug, which was obtained by Queensland from colonies established in Western Australia, is being bred in Brisbane and liberated in various infested districts, and it is hoped that this recent importation will achieve some considerable measure of success in a problem, the successful solution of which along other lines appears somewhat doubtful.

The various field stations of the general entomological branch are located in the most appropriate centres for the adequate performance of the duties allocated to them for the time being. A reasonably good reference library is supplied to each station and it includes complete sets of the more important economic entomological journals. A suitable range of microscopes and general laboratory equipment is supplied in each case, but as little capital expenditure is incurred on buildings as is compatible with the adequate discharge of the duties of the field stations. A station can thus be transferred with little or no loss of capital when it has discharged the functions for which is was established, thereby permitting a flexibility in the movement of staff officers which might not otherwise be attainable.

A State-wide scheme of entomological research has been devised in the Brisbane headquarters and is controlled therefrom, and each field station plays its part in the scheme, its precise function varying with the necessarily changing requirements of the situation. It is felt that the type of organisation just outlined is that best suited to meet the requirements of a general entomological branch in a State of such dimensions and diversified interests as Queensland.

## ACTIVITIES OF OTHER ENTOMOLOGICAL UNITS

Passing now to the activities of the other entomological research officers, it is noted that the veterinary entomologist and parasitologist, as his title indicates is associated with insect problems in live stock. Actually, however, he devotes most of his attention to helminthology, this arrangement being largely the outcome of the fact that the two most important veterinary entomological problems in this State, viz.: sheep blowfly and buffalo fly, are receiving a great dea' of attention from the Council for Scientific and Industrial Research.

The entomological officers of the Bureau of Sugar Experiment Stations are concentrating mainly on white grubs, beetle borer, and wireworms, and they have already amassed a great volume of valuable information on the life histories and control of these and other insect enemies of sugar-cane. A considerable measure of success has been achieved by them in the establishment of a parasite of the sugar-cane beetle borer, while recently the giant American toad has been introduced by the Bureau mainly for the control of white grub beetles.

An account of entomological research activities in Queensland would be incomplete without a reference to the work of the Commonwealth Prickly Pear Board, which has handled the biological control of prickly pear and which, in association with the Council for Scientific and Industrial Research, is now engaged on the investigation of the possibilites of the entomological control of other weed pests such as Noogoora burr and Bassia burr. The Board possesses field stations at Goondiwindi, Chinchilla and Gogango, as well as its headquarters at Sherwood in the suburbs of Brisbane. The success achieved in the control of prickly pear by the introduction of its insect enemies is too well known to require amplification in this brief survey.

The University of Queensland also plays an important part in entomological research in that a high proportion of the officers engaged in the study of entomological problems in this State are graduates of that institution, the Queensland Faculty of Agriculture having a lecturer on Economic Entomology on its staff. Furthermore, the Walter and Eliza Hall Fellow in Economic Biology was for many years engaged in blowfly and bunchy-top aphis investigations, projects of interest and importance to the stock owner and banana grower respectively.

The preceding paragraphs clearly indicate that the period of indifference to entomological research, which was world wide in its incidence, is happily a thing of the past in Queensland and a considerable staff of well trained and enthusiastic officers is now devoting attention to a large number of problems of outstanding importance. Furthermore, very appreciable progress has been made in the solution of many of these problems, and it is hoped and believed that still further progress will be achieved in the future.

# The Biological Control of Clidemia Hirta in Fiji

By

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Whilst engaged during a part of 1935 in making a study of insects attacking *Lantana* in Fiji, it was the writer's good fortune to come into direct contact with a type of biological control of weeds which was of considerable interest.

The plant, *Clidemia hirta,* commonly known as "Koster's Curse," as a member of the Melastomaceae, is a perennial herbaceous shrub with an erect stem which rarely exceeds a height of six feet. The simple leaves have veins of more or less the same size, diverging from the base and converging at the apex; there is no true midrib. This shrub is indigenous to Tropical America and is supposed to have been accidentally introduced into Fiji with coffee plants from British Guiana, some time prior to 1890. Soon after this, it began to assume the proportions of a major weed invading the permanent cultivations and native forests. Its spread into pastures was particularly serious as it soon formed a dense, matted growth up to six feet in height and thus greatly reduced the carrying capacity. Its phenomenally rapid spread was brought about by the introduced Mynah bird of India which fed freely upon the fleshy fruits.

About 1920, the Agricultural Department of Fiji made inquiries in Jamaica, British Guiana and Trinidad in order to determine whether any natural agencies were known to be holding the plant in check in its natural habitat. This brought before the notice of the local scientists a plant which had hitherto received little attention since it was of no economic importance in its native environment, with the result that it was not long before a new insect, *Liothrips urichi* Karny, was discovered feeding on the foliage. At that time, however, no importance was attached to the discovery as this thrips was not considered to have much effect on its host plant. In 1927 and again in 1929, detailed studies of the weed and its ecological complex were made in Tropical America by entomologists from Fiji. These investigators concluded from their surveys that *Clidemia* was being efficiently controlled by the combined effect of competing vegetation and a number of insect enemies, the chief of which appeared to be the thrips, *Liothrips urichi.* The fact that the activities of Liothrips were limited to some extent by native insect parasites suggested that this insect, if

freed of its natural enemies, should prove an even more potent factor in controlling Clidemia in Fiji than in its native habitat. In 1930 this insect was shipped from Trinidad and liberated on the island of Vitilevu, Fiji.

*Liothrips urichi* belongs to the family Phloeothripidae and the sub-order Tubulifera of the order Thysanoptera. Both the adults, which are black, and the nymphs, which are conspicuously bright red, are injurious to Clidemia. The thrips characteristically concentrates in large numbers on the young terminal shoots which very soon curl, turn brown and die off as a result of the insects' puncturing and sap-sucking, feeding habits. Plants which are heavily infested produce few flowers, if any, so that seed production and subsequent spread are considerably reduced. As the terminal foliage is destroyed, the nymphs move down the stems which likewise die back. With a young plant this die-back is apt to extend to the roots, but usually the roots are not injured and the plant produces new growth unless other conditions are unfavourable.

In Fiji, it is the less spectacular, disabling and weakening effect of this insect's attack on the weed in an actively competing plant community which has been responsible for the steady removal of "Koster's Curse." Under these typically tropical conditions, where plant growth is extremely rapid and vigorous, such plants as Para grass (*Panicum barbinode*), Sensitive Plant (*Mimosa pudica*), Mile-a-minute (*Mikania scandens*), Desmodium (*D. trifolium*) and other climbing and semi-climbing types, rapidly over-run the stunted weed and cause heavy defoliation and, eventually death. In the short period of five years, the vegetation on several large areas around Suva has, without manual labour, been changed from a dense growth of "Curse" to useful nutritious fodder plants. As the effect of the thrips attack is dependent upon the competition of other vegetation, it is obvious that where grazing is heavy useful competing vegetation will have little chance to overgrow the weed. Thus in Fiji, as in Australia, pastoralists are confronted with a weed problem in which the question of overstocking is of major importance. At the Tailevu Dairy Settlement, Vitilevu, whereas formerly settlers had to cut this weed every six months, such cutting now is only required once in two years and then only where grazing has been heavy.

In view of the fact that the thrips has made such rapid progress in so short a space of time, it seems highly improbable that as yet a balance has been struck between the thrips population and that of its host plant, *Clidemia hirta;* nevertheless, even in this short period, truly remarkable results have been achieved. The weed is no longer the dominant feature along roadsides and in grazing paddocks; over considerable areas where grazing has not been too heavy, the weed is rapidly being replaced by nourishing grasses and legumes; weeding costs have been reduced by 75 per cent; and, on newly exposed surfaces, the plant no longer comes up in a solid sward.

# Legume Inoculation

## PROGRESS OF THE WORK IN WESTERN AUSTRALIA

By

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The following are brief notes of portion of an address given by Mr. Pittman before the first meeting of the Western Australian Branch of the Australian Institute of Agricultural Science, at Perth on December 6, 1935.—Ed.

The pure culture method of legume inoculation was first launched by Nobbe and Hiltner in Germany, in 1896, the organism being grown on nutrient gelatine and the cultures being distributed under the name of "Nitragin." For various reasons, however, this method was found unsatisfactory. In 1902 the United States of America Department of Agriculture commenced the distribution of pure cultures on dried cotton, but this method also was found unsatisfactory. Liquid cultures followed with rather more success. It remained for Harrison and Barlow in Ontario, Canada, however, to work out a completely satisfactory medium. Their cultures were grown on agar, and were used with success on all sorts of soil and with all the common legumes. In extensive trials extending over ten years, favourable results were obtained in 65 per cent. of the cases.

Thornton at Rothamsted (6) worked out a very successful method of growing the lucerne bacterium by cultivating it on an agar medium made from an extract of lucerne roots and certain mineral salts. One of these lucerne cultures was obtained from him in 1926 by Mr. F. W. Strack, General Manager of the London Office of the Primary Producers' Bank of Australia, and forwarded to Western Australia, where the organism was sub-cultured and distributed to a limited number of farmers in various parts of the State by the then Botanist and Plant Pathologist, Mr. W. M. Carne, with the result that successful stands of lucerne were obtained in many places where success with this crop had not previously occurred. The same organism has been sub-cultured on artificial media ever since and is still giving as good results as when it was first obtained, ten years ago.

No attempt to encourage the widespread use of the cultures appears to have been made, however, in Western Australia until 1929. Since that date a large number of other cultures has been obtained from various foreign sources, and some have been isolated in the laboratory from nodules occurring naturally on the roots of particular legumes. At present, cultures for the inoculation of clovers, lucerne and related plants, garden peas and their allies, W.A. blue lupins, soy beans, sulla, French beans, cowpeas and their allies, and Lotus species, are being distributed at the rate of about one thousand per annum, all being

paid for at the rate of 1/6 for a 10z., 2/6 for a 20z., and 5/- for an 8oz. bottle (5). Since 1926, over 2,500 cultures have been distributed to farmers in Western Australia, and several hundred have been forwarded to the Eastern States.

Recently it has been shown by a number of workers in America and elsewhere (*vide,* particularly the work of Allen and Baldwin at the University of Wisconsin (1))—that for the inoculation of any particular legume, there exists a large number of strains of nitrogen-fixing bacteria, some of which are very much more efficient in fixing nitrogen than others. Moreover, these two workers have shown that a very efficient strain, when introduced into the soil, gradually loses its effectiveness as a stimulator of legume growth, as it goes through a series of "plant passages" on the roots of the same kind of legume with the growing of successive crops of the same kind on the same parcel of soil. They have also shown that inefficient strains gradually become more efficient as they go through a greater or less number of such plant passages. But an efficient strain continues at the same level of efficiency if propagated on a suitable artificial medium, and an inefficient one does not improve under such conditions (1). The inference from the work of these investigators, although they do not appear to make it themselves, is that some strains in the soil will be in the "up" condition while others are in the "down," and that the yield of any given field of naturally-inoculated legumes, other things remaining equal, will fall somewhere between the theoretically possible maximum and minimum, the exact point depending on the relative abundance on the roots of effective and less effective strains of nodule-forming bacteria.

Now the work of Dunham and Baldwin (3) shows quite clearly that the strain which first enters the root system of a legume, tends to set up a condition therein, as a result of which it is much more easy for further individuals of the same strain to infect the same root system than it is for individuals of a different strain.

The nett result of the above considerations will be that, in a field containing a mixture of efficient and inefficient strains—and this seems to be the normal condition—the very best possible yields will be obtained by deliberately inoculating the seed, every time the particular crop is to be sown, with the best tested strain of bacteria, even though the soil is already heavily infected with organisms capable of forming nodules on the roots of the legume concerned. This conclusion has been experimentally confirmed by Thornton with clovers in England (7).

Speaking generally, Allen and Baldwin (1) have shown that the most efficient strains form only very few, but very large, nodules on the roots, while inefficient strains form very many but much smaller ones.

The relative effectiveness of various strains can be experimentally determined by growing sterilised seeds, subsequently inoculated with various strains, in sterilised soil, or Erlenmeyer flasks containing a suitable medium (1, 2, 6).

Numerous reports have been received by the plant pathology branch of the Department of Agriculture in Western Australia as to the very great benefits which have resulted from the use of cultures for the inoculation of subterranean clover seed, Western Australian blue lupins, field peas, cow peas, lucerne, etc. In the case of subterranean clover, where the seed is not deliberately inoculated, the individual plants on new country frequently form rosettes of not more than six inches in diameter. Where the seed is inoculated with the bacteria, however, before planting, and sown on the same type of soil on the same farm, it is not uncommon for every plant in a field to cover a diameter of three feet or more in the first growing season after sowing. In other words, instead of having to wait for three or four years for really good stands to result, perfectly satisfactory stands frequently follow inoculation of the seed in the first year of growth.

A full account of the modified medium on which the cultures are grown in Western Australia, together with directions for inoculation of the seed, method of sowing, etc., will be found in the June issue of the Journal of the Department of Agriculture for Western Australia for 1935, pp. 105-116, or in Leaflet 323, 1935 edition, issued by that Department, which is available free of charge on application to the Director of Agriculture, Perth, W.A.

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# Bunchy Top Disease of Bananas

## REHABILITATION OF THE BANANA INDUSTRY IN NEW SOUTH WALES

By

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The bunchy top epiphytotic in banana plantations in New South Wales during the period 1922-1927 furnishes the most spectacular instance of intense economic stress yet caused by a plant disease in Australia. Although banana culture at this time did not constitute an extensive industry, it had expanded rapidly as a post-war, closer settlement development and was the sole means of livelihood of approximately one thousand families in New South Wales, as well as supporting important subsidiary industries. It was also a highly capitalised industry in which the Repatriation Department had invested generously, and which land salesmen had "boomed" so much that bearing plantations realised as much as £300 per acre and virgin boulder-strewn slopes changed hands at £150 per acre as plantation sites. Such capital outlays may have been justified had not bunchy top intervened, since with the ruling high prices for banana fruit good incomes were made and the towns of Tweed Heads, Murwillumbah and Mullumbimby went through a period of prosperity of the gold-rush type.

The bunchy top disease made its appearance in plantations during the early stages of development of the industry, in all probability being introduced in 1913 by the planting of infected banana suckers imported from Fiji. By 1922 there were approximately 5,500 acres planted to bananas in New South Wales and bunchy top was then regarded as a serious menace to the industry. Unsuccessful attempts were made by the New South Wales Government to check the spread of the disease by the establishment of "buffer" zones between affected and unaffected areas, but by 1925 the area under bananas had dwindled to 1,500 acres and production had decreased from 433,000 tropical (1.5 bushels) cases in 1922 to 60,000 tropical cases in 1925. Fully 90 per cent. of the land in banana culture in 1922 ceased production and owing both to its highly capitalised condition and specialised nature, being mainly hilly, stony land, there was no other crop which could replace bananas, at least, on the same lucrative basis. Many individuals who had invested in banana growing were faced with financial ruin and much unemployment prevailed among plantation workers and those engaged in the subsidiary industries of haulage, casemaking, etc. The Governments lost heavily on account of failure of Soldiers' Settlement schemes in the affected areas and fall of rail freight, income taxes, etc.

In 1924-25 an investigation of the disease as a co-operative project of the Governments of the Commonwealth, New South Wales and Queensland, demonstrated that bunchy top was a virus disease which was disseminated by the planting of infected suckers, and that the banana aphid, *Pentalonia nigronervosa,* was the chief and possibly only insect vector. Examination of the contributory factors to the epiphytotic indicated that while this insect was an important agent in natural transmission of the disease, the part it had played in the downfall of the industry was equalled in importance by the existence of large numbers of centres of infection which had been establishd by the planting of infected suckers over wide areas. This, together with observations that the bunchy top virus had a narrow host range while the vector had limited feeding habits, and that the situation was not complicated by the existence of wild hosts in the affected territory, made possible the formulation of control measures for district application. These involved registration of plantations, eradication of diseased plants and controlled replanting with known disease-free stock.

It was thought that a scheme of this type would collapse if left entirely to the goodwill of the planters, and in 1927 proclamations and regulations were gazetted under the New South Wales Plant Diseases Act 1924, proclaiming quarantine areas and governing movement of suckers from one district to another, permits to plant, and procedure in connection with the eradication of diseased plants. Since November, 1927, the banana industry in New South Wales has been under Government control, but this control has been mainly one of guidance rather than policing, and the success which has attended efforts to rehabilitate the industry must be attributed as much to the co-operation of planters and their organisations as to any other influence. Use has certainly been made of the law courts in enforcing the control regulations but the number of prosecutions has been comparatively small.

Eradication of diseased plants appeared to be the most difficult problem in the control programme but since many plantations, being totally infected, were worthless and as stock had overrun and eaten down many others, this portion of the scheme was carried out with less trouble than was anticipated. It is noteworthy that the New South Wales Government was not called upon to provide funds directly for eradication. The division of the affected areas into "zones," which to some extent demarcated badly affected districts from lightly affected ones, allowed discrimination in administration of the regulations and enabled eradication and replanting to proceed with a minimum of friction.

In 1927, representative banana growers in the various districts were elected to committees under the title of zonal committees to assist the Department of Agriculture in the application of the regulations and in February, 1928, four full-time inspectors were appointed as officers of the Department to supervise

eradication and the issue of permits for restocking. At a later date the duties of the zonal committees were absorbed by the various branches of the Banana Growers' Federation, and as the industry grew additional Government inspectors were appointed.

The control campaign early showed signs of being successful and gave encouragement for its continuance. Suckers for restocking in the first instance came mainly from known disease-free areas in Queensland and later from disease-free zones in New South Wales. Bunchy top did not appear for some years in most of the control-planted plantations. During the first two years of reconstruction of the industry the area planted was not extensive, which is attributable to the hesitancy of growers to invest money in banana growing while the memory of the ravages of bunchy top was still fresh. This was perhaps fortunate for the control scheme as it gave time for more complete eradication before the heavy planting period arrived. The accompanying table, compiled by Mr. H. W. Eastwood, Senior Fruit Instructor and Officer-in-Charge of eradication and replanting, indicates the rate of expansion of banana growing from 1928 onwards.

Table showing Banana Acreage and Production in New South Wales, 1928-35

| Year | Acres | Production (Tropical cases) |
|---|---|---|
| 1928 | 1,992 | 74,703 |
| 1929 | 3,340 | 81,455 |
| 1930 | 4,959 | 117,120 |
| 1931 | 6,256 | 216,756 |
| 1932 | 7,443 | 468,376 |
| 1933 | 12,846 | 498,694 |
| 1934 | 22,287 | 875,867 |
| 1935 | 20,133 | 1,000,000 (estimate) |

Until 1932 the growth of the industry was gradual and very little bunchy top was to be found in the newly established plantations. A new difficulty presented itself, however, just when both growers and the Government were feeling proud of the accomplishment of rebuilding a ruined industry. High prices for banana fruit prevailed during the winter of 1932 and a "banana boom" commenced, resulting in the planting of an additional 5,400 acres in the spring. This was followed by the planting of another 9,643 acres in the spring of 1933. Such rapid extension of the area under bananas was viewed with alarm by the Government as it was obvious that overproduction of fruit must result and that attendant low returns would make many plantations unpayable. The Government had no statutory powers to prevent the planting of healthy bananas and could only issue warnings of the dangers involved. It was feared that the bunchy top control scheme would be seriously challenged by unremunerative returns to growers; in fact in 1934, when the depression in

prices of banana fruit commenced, plantation labour was greatly curtailed and there was noticeable a marked increase in neglect of detection and eradication of diseased plants.

Even before this period of overproduction, in 1933, a slight increase in the prevalence of bunchy top was apparent. Success in maintaining plantations free from the disease in the past made some growers indifferent to the dangers of bunchy top, and this together with the fact that plantations established in 1928 and 1929 were now becoming less productive, led to considerable neglect in promptly dealing with diseased plants. There were no serious outbreaks, however, until 1935 when low prices had been operating for some time and many plantations had become as much a liability as an asset. Bunchy top again became well entrenched in a few limited areas in the Tweed River district and called for special action and increased vigilance on the part of the inspectors. Such outbreaks have not so far imperilled the industry but they have served as a warning that bunchy top must still be reckoned with and that the fullest co-operation is necessary in combatting it.

The bunchy top control campaign provides an interesting demonstration of field control of a virus disease and may be noted also as an instance of successful application of legislation in plant disease control. Virus diseases rank amongst the most important maladies affecting crop plants and are also perhaps the most troublesome to combat. The problems they create are intensified by their insect vector phases which appear to offer insuperable barriers to solution. In general, the method of attacking virus diseases is simple but laborious, depending primarily on the prompt detection and removal of diseased plants to reduce sources of infection. In very few instances only can use be made of resistant varieties. The application of control measures on a district scale, as has been done with bunchy top, is unusual and would be practicable in the case of very few virus diseases. The narrow host range of bunchy top and absence of wild hosts are the factors mainly responsible for the success which has been achieved. Localisation of the banana industry in New South Wales to limited territory has, however, also been important since it has assisted growers in becoming well organised and has fostered co-operation with the Government.

# Some Principles of Statistics and their Application to Agricultural Experiments

By
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## INTRODUCTION.

This paper is the first of a series of four articles dealing with the elementary principles of statistical method in its application to biological research, and in particular to agricultural experiments. The biometrical problems which have been submitted to me in the last few years have come from many different sources, and cover a wide field of research. Their variety and extent indicate that there is a definite demand for a simple outline of the theory underlying the use of statistical formulae. The suggestion was therefore welcome to me that a short series of articles on this subject might be useful to readers of this journal.

It is hardly necessary to stress the importance of sound principles being employed in both the planning of experiments, and the subsequent analysing of results, because to-day it is well realised that in conducting experiments of a quantitative nature, adequate repetition, careful planning and precise analysis are needed before valid conclusions can be drawn. Statistical theory can help us first to make satisfactory plans, and later to draw the correct conclusions from the resulting data. Through the researches of such men as Professor R. A. Fisher, the experimental worker to-day is able to use certain definite rules based on biometrical theory, as a guide in planning and analysing his work. It is hoped that this and the following papers will give the reader some idea, not only of the statistical rules and the formulae which he applies, but also, in a measure, of the principles on which they are based. The subjects that will be dealt with in the four papers are:—

1. Simple ideas of probability, and a general consideration of frequency distributions.
2. Tests of significance, including the analysis of variance, particularly in application to field experiments.
3. Correlation, and regression, including the analysis of covariance.
4. Time series, and some special distributions. Tests of goodness of fit.

The article of outstanding interest to agriculturists is probably the one including the analysis of variance, on account of its wide application to field experiments. It has therefore been put as early in the series as possible. The

first paper is a necessary preliminary to an understanding of the remainder. The terms in common use, such as level of significance, variance, standard error, can all be explained only by reference to probabilities and frequency distributions.

Correlation and regression coefficients are useful when two or more variable factors are under consideration, and a measure is needed of the association between them, as, for instance, the yield and height of plants, or between yield and weather conditions. By means of the analysis of covariance, correlation and regression coefficients have a further important function in agricultural experiments. With permanent crops, such as tea, it is possible to take observations over untreated areas in one year, and use the results in a very simple way to make corrections for soil differences in the yields of treated plots on the same areas in subsequent years. This provides a very effective means of allowing for soil heterogeneities, and in some instances will very considerably reduce the error of an experiment. Analysis of covariance also provides the best method of correcting for stand in experiments with such crops as potatoes, where unevenness of stand is accidental and can seriously affect the result. It may sometimes happen that a change in soil fertility will affect two factors in the same manner, and this would give a false idea of the correlation between them. Analysis of covariance enables us to estimate what this correlation would be, if it were independent of major differences in soil fertility. It is therefore apparent that correlation, regression, and covariance have an important bearing on agricultural experimentation.

The last paper will include the fitting of mathematical formulae to time series, such as growth curves and changes of weather with time. Also, in this paper, we shall return to frequency distributions, and consider some special distributions such as the Binomial and Poisson series, which have applications to plant breeding, in the testing of Mendelian ratios, and to the estimation of infection by counting methods. We shall consider in this paper also the important tests of the goodness of fit of observed data to the theoretical distributions.

It is hoped that, at the conclusion of this series of articles, the reader will feel disposed to study such books on the subject as Statistical Methods for Research Workers by R. A. Fisher, and The Methods of Statistics by L. H. C. Tippett. The former contains the tables which are needed for tests of significance, and is therefore essential in carrying out any such tests.

## PROBABILITY.

The conception of probability is fundamental to all statistical work, so it is important first to have a grasp of its meaning. It is usual to take examples from games of chance, such as coin tossing, card drawing or dice throwing, in explaining the laws of probability, because these give ideal cases, freed from the restrictions and limitations which often complicate the application of

probability to physical problems. Once the simple rules are understood, they can be applied, with the necessary caution, to practical problems facing the experimental worker.

Starting with a penny which is perfectly balanced and a method of tossing which does not favour either heads or tails, we cannot say with any certainty when we toss it once whether a head or tail will turn up. Toss it six times and we still do not know how many of the six tosses will give heads. But keep on tossing it, say a million times, then we can say with reasonable certainty that we should get very close to 500,000 heads and 500,000 tails. The more often we tossed the penny, the nearer should we get to equal numbers of heads and tails. We say the probability of a head is $\frac{1}{2}$, because in a very large number of tosses we should expect half the number of results to be heads. If we throw an unbiassed die, the probability of any special number turning up, the five, say, is 1/6, because in a very great number of tries it is found to occur 1/6 of the times. The probability of an even number (2, 4, or 6) occurring is $\frac{1}{2}$, because in a great many throws half of them would give even numbers, and half odd. The probability of throwing some other number than the five, is 5/6, because in a very large number of throws, 1/6 of them would be fives, and 5/6 of them not fives.

These are particular illustrations of the following general definition: The probability of an event under given circumstances is the ultimate value, as the number of observations is indefinitely increased, of the ratio of the number of times the event happens to the total possible number of times.

It can be expressed more simply by saying that if we could imagine an indefinitely large number of trials, the probability of an event is the fraction expressing the number of successes divided by the total number of trials. There are a number of different ways of defining probability, but this is the one on which most statistical theory is based. It is obvious from the definition that a probability is just a number, which cannot exceed one, since it is the fraction of the number of trials in which the event occurs. It is thus a positive number, whose value lies between 0 and 1. The following important rules are easily deduced from the definition:

1. If the probability of an event occurring is p, then the probability of its not occurring is $1 - p$.
2. If an event is certain to occur, its probability is 1.
3. If an event is certain not to occur, its probability is 0.
4. If the probabilities of each of n events, no two of which can occur together, are $p_1$, $p_2$, $p_3$ . . . . . $p_n$, then the probability that one or other of them will occur is the sum of the probabilities, $p_1 + p_2 +$ . . . . . $p_n$. For example, the probability of throwing an even number with a die is the sum of the probabilities of throwing a two, a four and a six; i.e., $1/6 + 1/6 + 1/6$, or $\frac{1}{2}$.

5. If the probabilities of each of n independent events are $p_1$, $p_2$, $p_3$ . . $p_n$, the probability that they will all occur together is the product of their probabilities, i.e., $p_1 \times p_2 \times p_3 \ldots . \times p_n$. For example, if 2 pennies are tossed, the probability of both giving heads is $\frac{1}{2} \times \frac{1}{2}$, i.e. $\frac{1}{4}$.

## FREQUENCY DISTRIBUTIONS.

Suppose we have 12 dice, throw them all and note the number of times the six occurs in each set of 12 dice . If we count the number of throws in which sixes appeared 0, 1, 2, 3 . . . . . 12 times, we obtain what is called a frequency distribution. This was actually done by Weldon, and the results quoted by Professor Edgeworth in the eleventh edition of the Encyclopædia Brittanica (Vol. XXII, p. 394). Twelve dice were used, and the whole set of 12 were thrown 4,096 times. The results were:

| No. of times 6 appeared | | No. of throws |
|---|---|---|
| 0 | ..... | 447 |
| 1 | ..... | 1145 |
| 2 | ..... | 1181 |
| 3 | ..... | 796 |
| 4 | ..... | 380 |
| 5 | ..... | 115 |
| 6 | ..... | 24 |
| 7 | ..... | 7 |
| 8 | ..... | 1 |
| 9 | ..... | 0 |
| 10 | ..... | 0 |
| 11 | ..... | 0 |
| 12 | ..... | 0 |
| | Total ..... | 4096 |

Thus in 447 throws a six did not turn up at all, one six in each set of 12 dice occurred 1145 times, two sixes occurred 1181 times, and so on. In none of the throws did as many as 9 sixes appear together. The average number of sixes per throw of 12 dice could be calculated by finding the total number of sixes thrown and dividing this by the total number of throws, i.e., 4096. Eight sixes occurred together once, 7 sixes occurred 7 times, thus in these 8 throws there were 8 + 49 sixes. In 24 of the throws there were 6 sixes, so these contributed 24 × 6 to the total number. In the same way the 5 sixes contributed 5 x 115 to the total number of sixes and, proceeding in this way, we see that the whole number of sixes that occurred was: 0 x 447 + 1 x 1145 + 2 x 1181 + 3 x 796 + 4 x 380 + 5 x 115 + 6 x 24 + 7 x 7 + 8 x 1, which is equal to 8191. Dividing this by 4096, we

find that the average or mean number of sixes per set of 12 throws is 2.000. On looking at the distribution one sees that the observations cluster round this mean value, 2, the frequencies tailing away on each side. This is characteristic of most of the frequency distributions with which we shall be concerned. Using the mathematical theory of probability, we can calculate the relative values of the frequencies of 0, 1, 2 . . . . . sixes per throw when the whole set of 12 dice was thrown an infinitely great number of times. The actual frequencies would depend on the numbers of throws. Thus in a series of two million throws, one would expect about twice as many sets of 4 sixes as in a series of one million throws. With 4096 throws, the frequencies in the different classes would be only approximately proportional to the frequencies calculated mathematically. As the number of throws is increased, the resulting frequencies tend to approximate more closely to the theoretical distribution. Thus the observed frequency distribution is really a sample from the theoretical distribution of an infinite number of throws. This theoretical distribution is called the hypothetical infinite population. Any single throw, or any group of throws, can be regarded as a sample from this hypothetical population.

There are many other types of frequency distribution. The numbers of persons in a community having blue, brown, green or grey eyes form a frequency distribution with four classes only. The frequency distribution which we considered first had thirteen classes, corresponding to the values 0, 1, 2, 3 . . . . . 12 for the number of sixes occurring per throw. A distribution may have an unlimited number of classes, as, for instance, when the variate being considered is the number of children in a family and the frequencies are the numbers of families containing the different numbers of children.

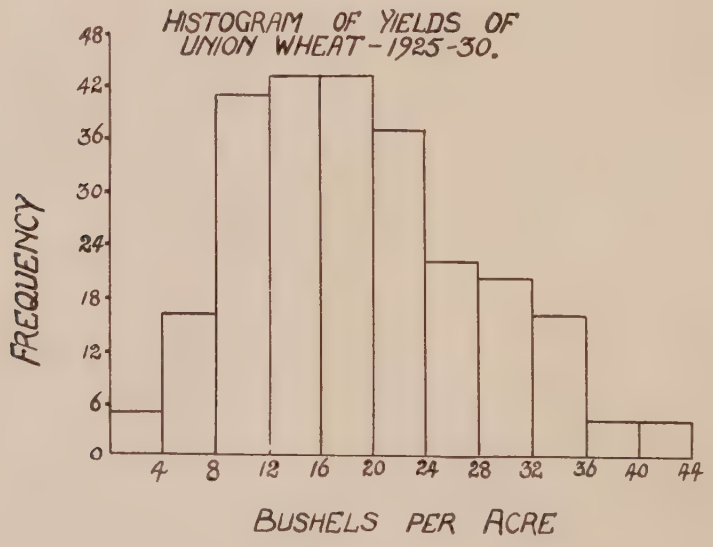
In all of these illustrations, the variation was discontinuous, that is to say, the classes were defined either by numbers which could differ only by finite amounts, as 0, 1, 2, 3 . . . ., or by the presence or absence of some definite characteristic in the individuals. In some instances, however, variation is continuous, as in the measurement of the heights of wheat plants, where the variate may have any value within a certain range. It is usual in such examples to fix arbitrary class values and count the number of individuals falling between the limits of each class interval. For instance, in examining the heights of wheat plants, we might take intervals of one inch, and find the number of plants whose height was between 9in. and <10in., the number between 10in. and <11in., between 11in. and <12in. and so on.

Graphs are useful in demonstrating the general character of observed frequency distributions. There are two standard ways of constructing frequency diagrams, which can be illustrated by plotting the observations in the following table:—

FREQUENCIES OF YIELDS OF UNION WHEAT IN FARMERS' TRIALS IN N.S.W., 1925-30

| Bushels Per Acre | Frequency of Occurrence |
|---|---|
| 0 < 4 | 5 |
| 4 < 8 | 16 |
| 8 < 12 | 41 |
| 12 < 16 | 43 |
| 16 < 20 | 43 |
| 20 < 24 | 37 |
| 24 < 28 | 22 |
| 28 < 32 | 20 |
| 32 < 36 | 16 |
| 36 < 40 | 4 |
| 40 and over | 4 |
| TOTAL | 251 |

(The information in this table is taken from the results of the Farmers' Trials published in the N.S.W. Agricultural Gazette. The extreme variability is due to the variety of seasonal and field conditions under which the trials have been conducted.)




In drawing the graph, take the value of the yield as the variate x, measured along the horizontal axis, and divide the axis into ranges corresponding to the class intervals. Take the frequency in any class as the y variate. On each of these ranges, construct a rectangle, equal in area to the frequency in the corresponding class. In this way we obtain a histogram. The total area is equal to the total number of observations, 251. Ideally, the probability of

getting an observation in any class is $\frac{\text{area of rectangle in that class}}{\text{total area}}$ Actually such a limited sample gives only a rough estimate of the value that would be obtained if we increased the number of trials indefinitely.

The second method is to draw an ordinate through the mid point of each range, of height proportional to the frequency in that range, and then join the tops of these ordinates. In this way a frequency polygon is obtained. Though often used, it is not so satisfactory as the histogram.

If the number of observations could be increased indefinitely, and the class intervals made indefinitely small, we should obtain a smooth curve by either method. Frequency diagrams can also be used when the variation is discontinuous, though smooth curves could not be obtained, since the class intervals always remain finite.

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# TECHNICAL NOTES

## BACTERIOLOGICAL STUDIES ON MUSTY FLAVOUR IN BUTTER.

The occurrence of a defect in New South Wales butter caused by *Achromobacter* sp. has been encountered more or less frequently during recent years. The defect is known by the name "Musty flavour," so-called, no doubt, on account of its resemblance to the mustiness sometimes found in butter due to the influence of moulds. Judges of butter regard musty flavour as a serious type of deterioration, and in their official capacity as graders of butter, readily degrade or officially reduce the market value of any consignment in which musty flavour is found.

Some five or six years ago an officer of the Dairy Branch of the N.S.W. Department of Agriculture first recognised musty flavour as a definite butter defect and suspected some unusual kind of contamination as being responsible for it. Subsequently, a number of samples of musty-flavoured butter were received in the laboratory for bacteriological analysis. Dilution plates of the affected butter were poured, beef extract agar being used for the purpose. Four days after incubation at 30°C. the plates showed colony populations of variable types of micro-organisms. Micrococci were especially numerous, while rod-shaped bacteria of various types were present in fairly large numbers. No moulds appeared on the plates, and only in a few instances did colonies of yeast types develop. It was observed, however, that a peculiar penetrating musty odour accompanied all the beef extract agar plates. The thought that this odour was due to a particular organism and the possible relationship of such an

organism to the musty flavour in the butter was anticipated. Colonies were therefore picked on to beef extract agar slopes and those cultures which developed a musty odour were selected for further study and for use in the preparation of experimental butter.

While the analyses of numerous samples of musty-flavoured butter have always revealed the presence of the musty-odour organism, in no sample has this organism been found to be the predominating type. In some samples, counts of only 4,000 or 5,000 musty-odour bacteria have been associated with a million or more other bacteria. Most samples of typically affected butter, however, have shown counts of 30,000 to 40,000 musty-odour bacteria per gram of the sample.

Apparently very little work has been done on the occurrence of musty flavour in butter. Hammer (1) mentioned that musty odour in such equipment as churns may be absorbed by butter and that samples commonly develop a mouldy or musty flavour when moulds have grown on them. Ruehle (2) isolated from butter several species of Torula that produced musty flavour in experimental butter. No record, however, of an organism of the type herein described having caused musty flavour in butter has come under notice.

The condition may occur in consignments made from high-grade, well pasteurised cream. It may also occur in butter from factories where the conditions of manufacture are such that moulds would be unlikely to exert any influence. The flavour is not noticeable in freshly made butter but may appear subsequently, usually four or five days and often a week will elapse before the flavour develops. The degree of mustiness in different lots of butter from a factory may vary considerably. In fact, batches made on the same day and even individual boxes of butter may or may not develop the condition. In typically affected butter both the flavour and the aroma are characteristically musty.

The following is a description of the musty-odour organism isolated from musty-flavoured butter and used in the preparation of experimental butter:

*Morphology*: Rods occurring singly and in pairs—average size 1.1 by 2.2 microns. Preparations made from milk cultures show oval vacuolated rods in pairs and chains of three cells. Rods are non motile, gram negative and do not form spores.

*Agar colonies*: These develop well in 48 hours at 20°C. and are bluish-white in colour, translucent, circular, with entire margin, and raised, moist, shiny surfac Colonies show internal refractive surfaces to transmitted light.

*Agar slope*: Growth abundant, filiform, developing a creamy colour and penetrating musty odour.

*Gelatin stab*: Surface growth white and somewhat waxy; slight growth at depth; no liquefaction of medium.

*Litmus milk*: Medium gradually becomes alkaline; musty odour develops.

*Potato*: Scanty greyish growth.

*Fermentation reactions*: Growth but no acid or gas from glucose, mannite, dulcite, lactose, galactose, inosite, raffinose, saccharose, adonite, sorbite, or maltose. Nitrate broth reduced to nitrite. Indol not formed.

In an attempt to identify the organism described above, reference was made to Bergey's Manual of Determinative Bacteriology (2nd edition). While the characteristics of the musty-odour organism allowed it to be placed in the genus *Achromobacter,* efforts to identify the organism by comparing it with species of *Achromobacter* described in the Manual were unsuccessful. Records were found of several new species of *Achromobacter* isolated from eggs that cause musty odour in agar media, but these differed from the musty butter organism in other cultural characteristics. It is believed that the organism under discussion is an undescribed species of the genus *Achromobacter.*

In order to determine the relationship of *Achromobacter* sp. to the musty flavour in butter, experiments were conducted along the following lines: Fresh, sweet cream was pasteurised in an Erlenmeyer flask at 145°F. for 30 minutes, cooled to 70°F. and divided into three portions. To one portion a milk culture of *Achromobacter* sp. was added. Another portion was inoculated with milk cultures of *Achromobacter* sp. and *Streptococcus lactis.* The remaining portion was left uninoculated to be used as a control. The three lots of cream were then churned in a small glass churn. The butter grain was washed twice with sterile water, after which it was thrown on to a sterile board, salted and worked with sterilised wooden pats. The prepared samples were then wrapped in butter paper and placed in an ice box at 45°F. They were removed each day and examined by an experienced butter grader. Musty flavour developed in the two inoculated samples of butter in five days; the uninoculated sample remained untainted. When the inoculum was added to the prepared butter during the working process, musty flavour developed within four days. Samples inoculated with mixed cultures of *Streptococcus lactis* and *Achromobacter* sp. tended to become rancid before the musty flavour developed.

In an endeavour to locate the source of the organism found to be the cause of the musty flavour, several factories supplying this class of butter were visited. The surveys resulted in the organism being found in large numbers in the crevices of such wooden utensils as removable butter workers; the organism was also isolated from scrapings from a canvas hose pipe connected with the cold water pipe line at the churn, and from the wooden supports within a well. Apparently the organism is not numerous in water as its presence could not be demonstrated in the amounts (1/10 and 1/100 m.l) usually used in the analyses.

In the control of musty flavour in butter satisfactory results were obtained when the necessary attention was given to factory hygiene and precaution taken to use water of known purity in the manufacturing process.

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(1) Hammer, B. W. Dairy Bacteriology, p. 383, 1928.
(2) Ruehle, G. L. A. Keeping Qualities of Butter. Michigan State College of Agriculture & Applied Science, Tech. Bull. 102, 1930.

## RESISTANCE OF NICOTIANA SPECIES TO BLUE MOULD (*PERONOSPORA TABACINA* Adam.)

As the first step in an attempt to breed a variety of tobacco resistant to blue mould, a large number of species and varieties of *Nicotiana* have been tested for resistance to the disease at the Experiment Farms at Glen Innes and Bathurst. Preliminary tests were carried out at both Farms during 1934 and 1935. At Bathurst, the seedlings were grown in both heated and unheated seed beds, and in the absence of natural infection, several inoculations were made with spore suspensions of *Peronospora tabacina.* At Glen Innes, during the autumn and winter months of 1934 and 1935, the tests were carried out in a heated glasshouse, the seedlings being inoculated a number of times with heavy spore suspensions when in the 4-6 leaf stage.

A confirmatory test of all the material previously tested and of some additional lines was carried out in the glasshouse at Glen Innes during October and November, 1935, favourable conditions for disease development being maintained as far as possible. Except that it was unnecessary to heat the glasshouse, conditions were similar to those of the previous glasshouse tests. Observations were also made on seedlings in outside beds. Continuous temperature and humidity records were kept in the glasshouse. Temperatures were high, and the mean minimum recorded during the test was 46.0°F. The relative humidity was maintained at a high level, and a heavy epidemic of blue mould was obtained.

In recording resistance, a 0-6 scale was used, 6 indicating complete susceptibility. The periods elapsing between inoculation, first appearance of symptoms, and final destruction of the plants, together with extent of infection, any limitation of spore-production, and—in the case of surviving lines—growth subsequent to infection, were used in indicating resistance.

*Resistance in Nicotiana tabacum.*—Of over 250 varieties and strains of *N. tabacum,* none showed any seedling resistance likely to be of value in a breeding programme. Some of the varieties from certain regions, notably the

Central European countries, Nyassaland and the Argentine, appeared to possess a slight degree of tolerance, as indicated by the periods between inoculation, the first appearance of symptoms, and complete destruction of the plants. In all cases, this tolerance was more marked in the open beds than in the glasshouse.

In the November, 1935, test at Glen Innes, the varieties Criollo Correntino from the Argentine, and Cavala 39, a variety of uncertain origin, showed the greatest tolerance. Other varieties which have consistently shown a slight tolerance in the seedling stage are Bonanza from Nyassaland, Lampazo from the Argentine, Movadium and Pusa Type 28 from India, and Banat, Ghimpati, Samaneau and Szuloki from Rumania.

*Resistance in N. rustica.*—From observations made on twenty-one varieties of *N. rustica,* it would appear that although this species possesses a greater degree of tolerance than does *N. tabacum,* it is likely to be of doubtful value in a breeding programme. While a fairly wide range of tolerance was shown by these varieties, all may be seriously affected under favourable conditions. The symptoms of the disease were distinct from those shown by *N. tabacum,* chlorosis and leaf curl being much more marked. Resistance was indicated by the severity of these symptoms, by growth subsequent to infection, and by a reduction in spore production. The varieties used in the tests originated in various countries: Italy, Czechoslovakia, Canada, Russia, India, California, Brazil, Persia, Ecuador and Kohn. The varieties Ephiata, Erbasanta, Srebianka and the unnamed sorts, Italian G35/13 and United States G35/71 appeared to have the most useful resistance (reaction of 3-4).

*Resistance in introduced species of Nicotiana.*—The reaction of the following introduced species of Nicotiana was tested: acuminata v. grandiflora, acuminata v. parviflora, acuminata, affinis, alata, Bigelovii, Bigelovii No. 338, Bigelovii v. quadrivalvis, caesia, campanulata, caudigera, chinensis, comitiana, glauca, glutinosa, Langsdorffii, micrantha (N. miersii), multivalvis (N. Bigelovii v. multivalvis), nudicaulis, paniculata, plumbaganiflora, quadrivalvis (N. Bigelovii v. quadrivalvis), repanda, repanda v. pendulata, Sanderae, sylvestris, tabacum x sylvestris (amphidiploid), triangophylla, trigonophylla, triplex K, triplex 2036, triplex 2051, triplex 2052, tabacum x sylvestris F4, tabacum x sylvestris F5, and tabacum x sylvestris F6.

In several cases, different varieties or geographical races of a species were tested. Many of the species have already been tested by Angell and Hill (Counc. Sci. and Ind. Res. Bull. 65, 1932) who reported that all species were easily infected. Of the introduced species tested at Glen Innes, *N. Bigelovii var quadrivalvis, N. campanulata, N. nudicaulis* and *N. quadrivalvis* showed the greatest resistance, although none were equal to the more resistant varieties of *N. rustica.*

Several species hybrids received from Dr. Eghis of Russia were also included in the tests. *N. Comitiana,* which is a partially fertile amphidiploid hybrid

between *N. tabacum* and *N. rustica,* gave a reaction somewhat similar to that of *N. rustica.* The amphidiploid hybrid of *N. tabacum* and *N. sylvestris* was similar to *N. sylvestris* in reaction to blue mould. All four lines of *N. triplex* from Russia and the *tabacum x sylvestris* hybrids from California showed complete susceptibility.

*Resistance in Australian Species of Nicotiana.*—The first group of native species of Nicotiana tested at Glen Innes was composed of five species received from Professor Goodspeed, of the University of California. These species, *N. Debneyi, N. exigua, N. Goodspeedii, N. maritima* and *N. velutina* were first tested during the autumn of 1935, and the preliminary results indicated that high resistance or even immunity to blue mould might be expected in Australian forms. Consequently an attempt was made to obtain additional Australian species and the authors are grateful to Professor Cleland of the University of Adelaide and to Dr. Phipps, of the Waite Institute, South Australia, for a number of the native species used in the tests.

The origin and reaction of all native lines are given in Table 1. Of those species which have shown immunity, the three varieties of *N. Debneyi,* and *N. exigua* and *N. velutina* were tested several times at Glen Innes during 1935. The unidentified species from Bathurst, G35/60, has survived several tests both at Bathurst and at Glen Innes without any infection being evident. The unidentified species G35/147, which may be *N. excelsior* has only been included in the most recent test at Glen Innes. Of these five apparently immune species, it is considered that the 24 chromosome species *N. Debneyi* is most likely to be of value in breeding as it most closely approximates the American species in morphological characters.

TABLE I.—REACTION OF NATIVE SPECIES OF *NICOTIANA* TO BLUE MOULD.

| Species of Nicotiana. | Accession Glen Innes Number. | Origin | Reaction 0–6* |
|---|---|---|---|
| Debneyi | G35/14 | Paterson, New South Wales | 0 |
| Debneyi | G35/16 | Lord Howe Island | 0 |
| Debneyi | G35/17 | Dalley, Queensland | 0 |
| exigua | G35/15 | Dalley, Queensland | 0 |
| Goodspeedii | G35/18 | Koonamore Station, South Australia | 1 |
| Gossei | G35/60 | Musgrave Ranges, South Australia | 2 |
| Gossei | G35/80 | Waite Institute, South Australia | 2 |
| Gossei | G35/61 | Erlunda, Central Australia | 2 |
| Gossei† | G35/148 | Endunda Ranges, Central Australia | 2 |
| Gossei† | G35/149 | Hermannsburg, Central Australia | 2 |
| inglubra | G35/79 | Waite Institute | 2 |
| maritima | G35/28 | Hallett's Cove, South Australia | 1–2 |
| suaveolens† | G35/2 | Kyogle, New South Wales | 2 |
| velutina | G35/12 | Broken Hill, New South Wales | 0 |
| excelsior† | G35/147 | Diamantina River, Central Australia | 0 |
| unidentified sp. | G35/60 | Bathurst, New South Wales | 0 |
| unidentified sp. | G35/146 | You Yangs, Victoria | 2 |

† Species identification uncertain.
* 6 indicates complete susceptibility.

The species *N. Gossei* and *N. inglubra,* which appear to be very similar, but which are very distinct from the other native species, are stated by Professor Cleland to be chewed by natives of Central Australia, and it is possible that new and valuable characters might be introduced into commercial tobaccos by their use in hybridisation. *N. maritima,* a 16 chromosome species from the alkaline coastal soils of South Australia, has a very distinct reaction to blue mould, the most marked symptom being pronounced thickening and curling of the leaves. The unidentified species G35/2 from Kyogle, N.S.W., which is morphologically similar to *N. Debneyi,* but which is susceptible to blue mould, has been provisionally identified as *N. suaveolens.* *N. Goodspeedii* is a 20 chromosome species from South Australia which has a high degree of resistance to the disease.

It is significant, as indicating the possible origin of *Peronospora tabacina,* that all of the Australian species tested are more resistant to mould than any of the introduced species.

## SUMMARY

(1) Varieties of *N. tabacum* and *N. rustica,* and a number of introduced and native species of Nicotiana have been tested for resistance to blue mould.

(2) Some geographical groups of varieties of *N. tabacum* appear to show a slight relative tolerance to blue mould, but it is doubtful whether this tolerance is sufficient to be of value in breeding for resistance to the disease.

(3) *N. rustica* possesses a greater tolerance than does *N. tabacum,* but this tolerance is not high, and is of doubtful value in breeding.

(4) No resistance greater than that of *N. rustica* has been found in any of the introduced species. Some of these, if more compatible with *N. tabacum,* may be of some value in breeding.

(5) High resistance, and apparently immunity, is to be found in the Australian species of the genus. Some of these, and particularly *N. Debneyi,* may prove of value in crossing.

(6) High resistance has only been found in Australian species of Nicotiana, and this may be of significance as indicating the possible origin of *Peronospora tabacina,* the blue mould fungus.

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# HALO BLIGHT OF BEANS—SOME RELATIONSHIPS OF THE PATHOGEN.

Among bacterial plant pathogens there are features of morphology and of growth behaviour on culture media which render the segregation of certain groups possible. For instance, Burkholder (1) has suggested three such groups in the genus Phytomonas, viz., Stewarti, Campestre and Green-fluorescent groups. However, differentiation within these groups is somewhat more difficult. The minor differences among the members of the green fluorescent group are often such that it is difficult to know what differences should confer varietal distinction, and what should confer specific distinction. The same difficulty is further encountered in attempting to identify newly isolated strains of pathogens with species already described.

In Victoria, early studies revealed that the etiological agent of the Halo Blight disease of beans was a bacterium which differed from Burkholder's description of *Phytomonas medicaginis phaseolicola* (2) in only two minor details, viz., in that litmus milk was slightly peptonised and that no acid was produced from glucose and saccharose in the presence of peptone. Differences of this order for isolates of *Phytomonas medicaginis phaseolicola* have been reported by other American workers (3, 4) so that no taxonomic significance is attached to them.

However, differences no greater than these have been found between the Halo Blight pathogen and two other members of the green fluorescent group—one *Phytomonas mori* pathogenic to the mulberry, and the other, an unnamed organism pathogenic to the garden stock (*Matthiola sp.*). Table 1 shows in what respects these organisms differed in the cultural tests.

Inoculation experiments have proved that each isolate could reproduce typical symptoms on the host from which the isolations were originally made, but not on the other two hosts.

In attempts to support these differences, further tests have been employed and these are outlined in the following paragraphs.

A bacteriophage obtained from diseased bean seeds (5) was tested against each of the three isolates. It was found that while *Phytomonas medicaginis phaseolicola* (in the "smooth" phase) was lysed by the phage, the isolate from the stock and *Phytomonas mori* each appeared to be insensitive to its action.

As differences in phage sensitivity are usually correlated with differences in the antigenic constitution of bacteria, agglutination tests were carried out using an antiserum prepared against the "smooth" phase of *Phytomonas medicaginis phaseolicola.* Details of the preparation of this serum are given elsewhere (5). This serum which reacted to a titre of 2560 with the "smooth" strain of the bean organism was tested against fresh, living suspensions of the

TABLE 1—DIFFERENCES IN CULTURAL REACTIONS OF THREE GREEN-FLUORESCENT ORGANISMS.

| | *P. mori* | *P. medicaginis phaseolicola* | Organism from the Stock. |
|---|---|---|---|
| Gelatin liquefaction | – | + | + |
| Diastatic action | – | – | slight |
| Peptonisation of litmus milk | – | slight | – |

TABLE 2.—AGGLUTINATION * OF FRESH AND HEATED SUSPENSIONS.

| Organism | | Final Serum Dilution. 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
|---|---|---|---|---|---|---|---|---|
| *Phytomonas medicaginis phaseolicola* | Fresh | +++ | | +++ | | +++ | | +++ |
| | Heated | +++ | | +++ | | +++ | | +++ |
| *Phytomonas mori* | Fresh | +++ | | +++ | | +++ | | +++ |
| | Heated | --- | | --- | | --- | | --- |
| Stock Organism | Fresh | +++ | | +++ | | +++ | | +++ |
| | Heated | --- | | --- | | --- | | --- |

* The agglutination of the fresh suspensions was floccular and that of the heated suspensions, granular.

isolate from the stock and *Phytomonas mori* (both in the "smooth" phase). As a result, all three suspensions agglutinated in a floccular manner to the same titre, indicating the presence of some common antigenic substance. The nature of this relationship was brought out more clearly in a second test carried out after heating the suspensions at 100° C. for one hour—a treatment which destroys the heat-labile "H" antigen. The results of both these tests are given in table 2.

From these tests it is clear that the organisms under consideration each contain a closely similar, if not identical, heat labile antigen. They also indicate that *Phytomonas medicaginis phaseolicola* possesses a heat stable antigen which is not shared by either *Phytomonas mori* or the bacterium from Matthiola.

Correlated with this difference in heat stable antigenic structure are differences in sensitivity to a bacteriophage and also differences in pathogenicity. The results also support the statement of Rosen and Bleecker (6) that "the agreement between the pathogenicity tests and the serological reactions is perhaps the very best evidence of the reliability of serological reactions in determining relationships among plant pathogens."

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(5) Adam, D. B., and Pugsley, A. T. Smooth-rough variation in *Phytomonas medicaginis phaseolicola* Burk. Aust. J. Exp. Biol. & Med. Science, 12:193, 1934.
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## A MYCORRHIZA-FORMING FUNGUS OF PINUS.

For a number of years the sporophores of *Boletus granulatus* (L.) Fr. have been noted growing in plantations of Pinus in Australia. Owing to their almost constant association with members of the genus Pinus this species has, with several other basidiomycetes including *Rhizopogon luteolus* been generally regarded as a mycorrhiza former. However, no definite proof of this association has yet been advanced here. In order to throw further light upon this matter it was decided to undertake an experiment involving the inoculation of sterile pine seedlings with the fungus in question.

In Queensland, *Boletus granulatus* has been found growing in association with *Pinus caribaea, P. taeda, P. patula, P. radiata, P. echinata,* and *P. longifolia,* which are the chief species of exotic pines planted in Queensland. It has also been found growing apart from any conifers in swamps where the dominant tree species are of the genus Banksia. Reports of a fungus, which from the description given would appear to be similar to *B. granulatus,* occurring in eucalypt forests have also been received, and the author has recently found specimens in such locations. In any case it is evident that this particular bolete is not confined to an association with Pinus. Sporophores are to be found in Pinus plantations in Queensland throughout the warmer months of the year provided the soil is sufficiently moist. Where there is little humus present and the ground almost bare no sporophores are produced. The bolete is edible and readily attacked by rodents and marsupials.

In a number of cases in plantations of *Pinus spp.,* the thick mycelial threads attached to the base of the stipe of the sporophores of *Boletus granulatus* have, by careful digging been traced to the coralloid ectendotropic mycorrhiza on the pine roots.

Isolations were made from the sporophores of specimens of *B. granulatus* collected at various State Forest plantations in Queensland. The isolations were made by placing pieces of tissue which were removed aseptically from the

sporophores on agar plates in petri dishes and incubating at 27° C. Potato-dextrose-agar acidified to a pH of 5.2 gave good results as a culture medium. Malt-sucrose-agar gave the most vigorous growth of the several media used. The inoculum which gave the best results was obtained from the interior of the base of the stipe. Successful inoculations were also made with material removed from various parts of the pileus and stipe. In all cases young fresh sporophores gave the most satisfactory results.

Seed of *Pinus caribaea, P. taeda* and *P. patula,* was sterilised in mercuric chloride solution (1:1000) for three minutes and washed in sterile water and sown in autoclaved soil. The species noted were used as they take an important part in state forestry operations concerning exotic trees. The soil used was a loamy sand containing a small proportion of leaf mould. The containers were glass-sided root observation boxes constructed as described by A. L. Deans (Phytopathology, Vol XIX, IV, 1929) except for slight modifications.

The sowing was regulated to obtain twenty-four seedlings in each box as a final population, the seedlings being arranged in two rows. This spacing was adopted in order that a close network of roots might quickly be obtained against the glass. When a satisfactory root growth was visible the glass sides were removed and the root systems inoculated with a pure culture of *Boletus granulatus.* The seedlings in the boxes would at that time average ten inches in height, only primary needles being present. The plants were somewhat aetiolated owing to glasshouse conditions. The culture used as a source of inoculum was young, actively growing, and recently isolated. It was growing on malt-sucrose-agar with a pH of 5.2 obtained by acidifying the media with lactic acid. Small pieces of the culture were cut out of the petri dishes and placed on the soil surface amongst the roots where the glass sides of the boxes had been removed. Several such inoculations were made on one side of each box to be inoculated. Another useful method of obtaining a source of inoculum was to grow the culture of *B. granulatus* on sterilised oats (with husks attached), in Erlenmeyer flasks. Small portions of the mass of oats which becomes bound together with the hyphae can then be used.

After inoculation the glass sides and their covers were replaced. The boxes were then examined at intervals for the appearance of mycorrhiza. In eight weeks white mycelial threads were seen to be enveloping the new root buds and these rapidly assumed the form of coralloid mycorrhiza. Within a few weeks all the roots seen through the glass of the boxes on the sides which had been inoculated had mycorrhiza attached to them. The infection began at the inoculated side of the box and appeared later on the uninoculated side. Mycelial strands were visible linking up the individual mycorrhiza. These were particularly abundant in places where there was an accumulation of

humus. Boxes left uninoculated as controls showed no development of mycorrhiza.

The mycorrhiza were "gabelmykorrhiza" and corresponded morphologically with those occurring in the plantations at Beerwah. "Einfach" mycorrhiza were also present but appeared to be a young stage of the gabelmykorrhiza. The coralloid masses were initiated by the envelopment of a young root bud with a weft of hyphae. The bud then branched dichotomously, each new bud being in turn netted in by the hyphae.

The mycorrhiza may then branch again and yet again, resulting in the coralloid arrangement. The mycorrhiza average 2 mm. in length but they may be longer. The fungus appears to prevent any great increase in length. The branches of the root system in each mycorrhiza are usually closely bound together with a mycelial network from which hyphae extend into the surrounding soil, becoming particularly abundant in places rich in decaying vegetable matter where there is also a corresponding richness in mycorrhiza population. In the field where the soil is bare of other vegetation and has no humus layer, the mycorrhiza are limited to the top inch of soil and often are actually in the surface of the soil.

For the first few weeks after the formation of the mycorrhiza the hyphae are snow white in colour but later become light to dark brown.

Sections of the mycorrhiza show them to be ectendotropic in type as described by Mâlin, there being an external layer on the cortex of the root and an intercellular penetration of hyphae forming the characteristic Hartig net. In rare cases an intracellular growth of the fungus was found. In older mycorrhiza the intercellular growth was found between all the cells of the cortex of the root. The intercellular hyphae were frequently septate with swollen internodes. A tannin layer was often in evidence in the cortex and a granulated layer of cells two to three cells deep was present round the edge of the cortex. The granules were irregular in shape and almost filled the cells. It is thought that they might be sporangioles but nothing definite can yet be said on this point. The layer of hyphae on the cortex was often half as thick as the cortex and enveloped the root tips where the root cells were much reduced in number.

In addition to the experiments carried out in the root observation boxes, seedlings of *Pinus caribaea* and *P. patula* growing in pots were inoculated with a culture of *Boletus granulatus* growing on sterilised oats. The growth response was remarkable. The uninoculated pots showed little or no growth and finally died, whilst those inoculated grew vigorously and the foliage became a green healthy colour. The foliage of the controls was of a purplish red colour. Typical mycorrhiza developed in the inoculated pots.

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# The Australian Institute of Agricultural Science

## NEW SOUTH WALES BRANCH

At the annual meeting of the N.S.W. Branch held at Science House on February 21, discussion took place on the non-graduate membership clauses of the Constitution of the Institute, and members were of the unanimous opinion that the time-limit clause—i.e., that which provides for admission of non-graduates to corporate membership only during the first three years of existence of the Institute—should be deleted. Further modifications were also carried unanimously and the re-draft of Section 4, as agreed upon at the meeting is being forwarded to the Hon. Secretary of the Institute in Melbourne.

The presidential address by Prof. R. D. Watt dealt with "Landmarks and Problems in Australian Agricultural Science," an account of which will appear in the June number of this journal.

Election of office-bearers for the ensuing year resulted as follows: President, Dr. R. J. Noble; Vice-President, Mr. R. H. Anderson; Hon. Secretary, Mr. E. T. Edwards; Hon. Treasurer, Mr. N. S. Noble; Committee, Messrs. G. de V. Davis and J. G. Churchward. As local Vice-President of the Institute, Prof. R. D. Watt is also a member of the executive committee.

Principal E. A. Southee and Mr. J. G. Churchward were elected as additional delegates of the N.S.W. Branch to the Federal Council.

## SOUTH AUSTRALIAN BRANCH

The first social function to be held by the Branch took the form of a dinner, for members only, at the Southern Cross Hotel on 6th December, 1935. One official guest, the Minister of Agriculture, the Hon. A. P. Blesing, M.L.C., had been invited but was unable to attend owing to ill-health. The attendance comprised 28 members and the Press. The Branch President, in proposing the toast, "The Department of Agriculture," coupled with the name of the Minister of Agriculture, referred particularly to the desirability for co-operation between representatives of the three main fields of agricultural progress—research, education and extension. The Australian Institute of Agricultural Science offered a place for all three types of worker and provided unique opportunities for meeting in an informal and sympathetic atmosphere. Mr. Spafford, in responding on behalf of the Minister of Agriculture, drew attention to the unavoidable divergence in outlook between the extension officer and the research worker, and made a plea for a greater measure of appreciation of the other man's viewpoint He stated that marketing was a phase to which greater attention should be paid; in South Australia there was no public organisation which rendered any advice or assistance to primary producers in the matter of selling their goods. The toast of "The Australian Institute of Agricultural Science" was proposed by Dr. A. R. Callaghan, who spoke in appreciative terms of the good fortune that the Institute had in securing Professor Richardson as its Federal President for the critical period of inauguration and early development. In reply, Professor Richardson said that the rate of material progress had become so rapid that it was beyond the capacity of many nations to assimilate the results into their national structure. The world had been flooded with cheap high-class primary products, and governments had done everything within their power to check this progress by means

of tariffs and quota systems in order to protect the peasant system on which they depended. Australia, he added, should make the most of her natural resources, improve the quality of her products, and develop areas of country with an assured rainfall. We should take the long view that there is not an abundance of food in the world, were all restrictions on trade to be removed.

## QUEENSLAND BRANCH

The final meeting of the Branch for 1935 was held at the University of Queensland on 27th November. In the absence of Professor J. K. Murray, the Vice-President, Mr. R. Veitch, occupied the Chair. Mr. L. F. Mandelson, recently returned from a nine-months' visit to the United States, gave a most interesting discourse on the genesis and operation of the Agricultural Adjustments Act (A.A.A.) in that country, referring especially to the ways in which this legislation had affected production and marketing methods in the tobacco industry. Messrs. Wells, Gurney and Hines joined in the subsequent discussion. (The A.A.A. has recently been declared unconstitutional by the United States Supreme Court.—Ed.) Before the close of the meeting, the Chairman referred to the impending departure of Mr. W. A. T. Summerville on a lengthy visit to overseas agricultural research institutions and, on behalf of the Branch, wished him every success in his journeyings. Mr. Summerville suitably responded. The meeting closed with an informal social gathering at which supper was served.

The Institute is now firmly established in Queensland, and the meetings which have been held since the inauguration of the Branch clearly indicate that the Institute has met a long-felt need in this State. It is confidently anticipated that membership of the Branch will exceed 40 early in the next financial year. The first Annual Meeting of the Branch has been fixed for 27th March.

## TASMANIAN BRANCH

Two meetings of the Tasmanian Branch were held in December to enable Dr. R. A. Scott to give an account of his experiences on his recent research trip to Great Britain. The first was in Hobart when members were the guests of Mr. J. W. Evans, Entomologist. Dr. Scott stressed the desirability of extensive additions to the library facilities in Australia. He suggested that investigational institutions furthest from the main centres of world research should strive to have the most complete set of abstracting publications and as many of the original journals and books as finance would allow. In his opinion a library should be easily accessible to investigators and should form the central feature of any group of research buildings. The second meeting for those in the Northern part of the State was attended by members of the Veterinary Association and others.

The request of the Federal Secretary to consider the extension of the period for admission of non-graduates has been dealt with and it is the opinion of the Tasmanian Branch that Section 4 of the qualifications for corporate membership should be modified to allow the admission of non-graduatess after the three-year period, such admission to be subject to the approval of a special qualifications committee, and to be regarded as a recognition of some outstanding service to agriculture.

## WESTERN AUSTRALIAN BRANCH

At a general meeting of the Agricultural Scientists' Association of Western Australia on October 4th, 1934, it was decided unanimously that the Association should be disbanded

and a branch of the Australian Institute of Agricultural Science formed in its place. The office-bearers of the Branch for the remainder of the financial year are: President, E. J. Underwood, Ph.D., B.Sc.Agr.; Hon. Secretary & Treasurer, G. K. Baron Hay, B.Sc.Agric.; Committee, H. A. Pittman, B.A., B.Sc.Agr.; R. P. Roberts, B.Sc.Agric.; R. D. Royce (student member); F. L. Shier, B.Sc.Agric.; L. J. H. Teakle, Ph.D., B.Sc.Agric.

In order to mark the closure of the old Association and the inauguration of a branch of the Institute, a very successful function in the form of a dinner—at which over 50 persons were present—was held at the University refectory in November. Guests of honour included the Chancellor of the University, the Professor of Agriculture, the Public Service Commissioner, the Chairman of the Agricultural Bank Commission, the sub-Editor of the "West Australian," the President of the Royal Society, the Chairman of the State Committee of the C.S.I.R., representatives of the Veterinary & Chemical Institutes and the Secretary of the Royal Agricultural Society. Apologies for non-attendance were received from the Minister for Agriculture, the Leader of the Opposition and the President of the Royal Agricultural Society.

The first ordinary meeting of the Branch took place on 6th December, 1935. After routine business had been dealt with, a paper was read by the Plant Pathologist in the Dept. of Agriculture (H. A. Pittman) on "Nitrogen-Fixing Bacteria—Preparation of Cultures in the Laboratory and Their Use in the Field," an abstract of which appears elsewhere in this issue.

## WESTERN AUSTRALIAN MEMBERS OF THE INSTITUTE

Adams, A. B., B.Sc. (Agric.), Muresk Agric. College, Muresk.
Baron-Hay, G. K., M.C., B.Sc. (Agric.), Superintendent of Dairying, Dept. of Agriculture, Perth.
Burvill, G. H., B.Sc. (Agric.), Agricultural Adviser, Dept. of Agriculture, Perth.
Clifton, A. R. C., Irrigation Expert, Dept. of Agriculture, Perth.
Davenport, N., B.Sc. (Agric.), Senior Agricultural Adviser, Dept. of Agriculture, Perth.
Dunne, T. C., Ph.D., B.Sc. (Agric.), Research Officer in Agrostology, Agric. College, Muresk.
Gauntlett, G., B.Sc. (Agric.), Agricultural Adviser, Harvey.
Jones, K. E., B.Sc. (Agric.), Coorow.
Lapsley, R. G., B.Sc. (Agric.), Public Analyst, Yorkshire House, Perth.
Lightfoot, L. C., B.Sc. (Agric.), Agricultural Adviser, Roelands.
Lutz, K. T., B.Sc. (Agric.), Agricultural Adviser, Waroona.
Owen, R. C., B.Sc. (Agric.), Horticultural Instructor, Dept. of Agriculture, Perth.
Paul, R. A., B.Sc. (Agric.), Agricultural Adviser, Dept. of Agriculture, Perth.
Pittman, H. A., B.A., B.Sc.Agr., Dip. Ed., Plant Pathologist, Dept. of Agriculture, Perth.
Powell, H. R., B.Sc. (Agric.), Agricultural Adviser, Dept. of Agriculture, Perth.
Prowse, E. W., B.Sc. (Agric.), Doodlakine.
Prunster, R. W., B.Sc. (Agric.), Farm Manager, Agric. College, Muresk.
Riches, J. H., B.Sc. (Agric.), Lecturer in Agric. Science, Agric. College, Muresk.
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Snook, L. C., B.Sc. (Agric.), Agricultural Adviser, Dept. of Agriculture, Perth.
Southern, B., B.Sc. (Agric.), C/- Govt. Chemical Laboratory, Perth.
Stewart, A. M., B.Sc. (Agric.), Wagin.
Sutton, Geo. L., Director of Agriculture, Dept. of Agriculture, Perth.
Teakle, L. J. H., Ph.D., B.Sc. (Agric.), Plant Nutrition Officer, Dept. of Agriculture, Perth.
Thomas, I., Superintendent of Wheat Farms, Dept. of Agriculture, Perth.
Underwood, L. J., Ph.D., B.Sc. (Agric.), Animal Nutrition Officer, Dept. of Agriculture, Perth.

STUDENT MEMBERS.—J. Conochie, L. T. Jones, D. O. Norris, W. P. Norman, R. D. Royce, R. Roe, N. Tamblyn.

# Book Review

## "THE LAND NOW AND TO-MORROW"

### PROFESSOR STAPLEDON'S ILLUMINATING WORK.

Few books within recent years have been so inspiring yet discouraging, challenging, even provocative, as the latest contribution by Professor R. G. Stapledon, Professor of Agricultural Botany, University College of Wales, and Director of the Welsh Plant Breeding Station. This is no mere treatise on pasture improvement as might be expected by some readers from the nature of the author's duties at Aberystwyth, but a courageous and sincere attempt to visualise the encroachments of urbanisation on the British countryside and to provide a broad plan of land improvement based upon the pasture research work for which the Welsh Plant Breeding Station has won Empire-wide recognition.

The volume is the product of an alert mind and a vigorous personality. The tribute to his wife, who, since he arrived in Wales and devoted himself to the study of grassland and of rural conditions, motored him over 200,000 miles, frequently into most inaccessible places, is evidence of the activity which has contributed to the views expressed.

The result is a fascinating combination of recommendations and suggestions as the result of definite economic research and of theorising on the future of the British countryside. For his self-acknowledged presumption, he declares he is not in the least repentant and his comments on the economists (he talks of "economics run riot") have a refreshing candour and tang. While he is able to quote chapter and verse for the benefits derived from the use of wild white clover, leafy persistent perennial rye grass and persistent cocksfoot as a means of improving rough and hill grazings, he is disposed to disregard the difficulties of financing the plan of campaign which he outlines. This involves over a ten-year period the use of 1,375,000 tons of burnt lime annually with phosphates and seed supplies in proportion.

The Professor deplores the extent of the bracken-infested area (152,000 acres in Wales alone) and condemns the apathy which condones the thousands of acres "which should be labelled weed-land rather than grass-land." His views on this subject will come as a shock to the self-satisfied people who cherish the idea of the efficiency of British stock production methods.

The need for an all-embracing survey of land resources—a modern Domesday Book —is emphasised and he has no compunction in regard to compulsory resumptions on behalf of owner-occupiers. Nationalisation of land is not endorsed.

But the author paints on a wider canvas. He believes the reform of the calendar "to be one of the greatest, if not the greatest, of the problems that will have to be solved during the present century," he condemns the present examination system and pleads for wider opportunities for city residents to become country minded.

Several appreciative references are made to Mr. William Davies, a member of his staff, whose visit to Australia and New Zealand in the interests of pasture improvement will be remembered.

The volume is fully documented, authorities and statistics being freely quoted. The result evidences the convictions of a sincere lover of Britain who is actuated by the principle that the land is the property of posterity and that a wise planning of its agricultural resources is one of the clamant needs of the hour.

(Published by Faber & Faber, Ltd., English price 15/- net.)

P.G.G.

# Current Notes and News

## AGRICULTURAL SCIENCES CLUB, SOUTH AUSTRALIA.

Only one meeting of the Club has been held since the last issue of the Journal went to press This was the November, 1935, meeting, which was devoted to a series of three papers dealing with various aspects of the nitrogen problem in agriculture.

The first paper, entitled "The response of stubble-sown cereals to sulphate of ammonia at country centres in South Australia," was given by Mr. T. O. Mitchell, B.Agr.Sc., Advisory Officer of Nitrogen Fertilisers Ltd., Adelaide. This work arose from detailed investigations carried out at the Waite Institute over the period 1928-33 which had demonstrated that sulphate of ammonia was capable of producing large and profitable responses when applied to stubble-sown cereal crops. During the last two years, a comprehensive series of replicated experiments had been carried out within each of the principal agricultural divisions of the State, there being twenty separate trials in 1935. It was shown that in most cases oats and barley produced profitable responses to sulphate of ammonia, when applied in addition to superphosphate on unfallowed land. In general, the efficiency of the sulphate of ammonia dressing increased with increasing rainfall. Sulphate of ammonia was thought to have an important place on poor soils under mixed farming conditions, which involve rotational cropping and the frequent seeding of crops on stubble land. It was found that nitrogenous manuring, if properly carried out, had no deleterious effect on the malting quality of barley; on the other hand, under conditions of low available soil nitrogen, the quality could be improved. In conclusion, it was stated that considerably more investigation was necessary before the factors determining the degree of effectiveness of sulphate of ammonia as a fertiliser could be properly understood.

Mr. A. E. Scott, M.Sc., gave the second paper, which dealt with the fluctuations of nitrate and ammonia nitrogen in a soil supporting an established pasture of *Phalaris tuberosa* and subterranean clover. After discussing the methods employed and the sampling errors involved, Mr. Scott discussed the nature of the changes recorded over a seasonal period of several months' duration. The ammonia content of the soil had shown much greater variation than was usually found in arable soils, and amounted usually to between 5 and 10 p.p.m. The increase in soil ammonia resulting from fertilisation with sulphate of ammonia was not long sustained, some 50 per cent. having disappeared after approximately one week, under conditions favourable for nitrification. The resulting increase in nitrate content was less than might have been expected, and as downward leaching did not occur, it is probable that much of the added ammonia was rapidly utilised by the pasture and by soil micro-organisms. Pronounced fluctuations were recorded during the grazing periods, which were intensive but of short duration. The nitrate content of the soil, which was 11 p.p.m. at the beginning of May, had decreased by July 1st to approximately 1 p.p.m. and remained at less than 2 p.p.m. for a further period of 6 weeks. At any time during this period, one might be led to expect a response to the application of a nitrogenous fertiliser. Details of an experiment to ascertain the most favourable time of application were outlined.

The final paper, "Some aspects of the nitrogen problem in pastures," was given by Mr. H. C. Trumble, M.Agr.Sc., who first stressed the complexity of grassland problems compared with those relating to the more homogeneous crop units normally employed in agriculture. In all pasture work, the presence of livestock was to be regarded as a *sine qua non* of the environmental complex. The development of leguminous species also

formed an essential factor in the derivation of pasture nitrogen, and one had to consider among other things (1) the role of pasture legumes in fixing, utilising and donating nitrogen; (2) the nitrogen requirements of grazing animals, and (3) the fate of the nitrogen in animal excreta and its effect on immediate and ultimate production. From a variety of sources, including the results of work recently carried out on sheep and pastures in South Australia, a tentative working basis of 12 to 16 lb. nitrogen was assumed as the amount of digestible nitrogen required per annum for a sheep of 100 lb. producing 12 lb. wool. Certain of the poorer South Australian soils such as the Meadows sand and the Willalooka sand, if fallowed in the virgin state, appeared to contain sufficient available nitrogen for the requirements of at least a sheep per acre for one year, but in order to sustain or increase carrying capacity, it was necessary to cultivate suitable leguminous plants such as subterranean clover and lucerne, which were capable of accumulating large quantities of fixed nitrogen per acre. A vigorous crop of subterranean clover was capable of maintaining 4 to 5 sheep per acre even on the poorest of soils, but stock ailments were inevitable during the early years of the pasture, due to unbalanced nutrition. The development of subterranean clover appeared to be mainly dependent on suitable climatic conditions, favourable physical conditions of the soil, and an adequate supply of available phosphate. Data were presented which dealt with the effectiveness of pasture legumes in accumulating nitrogen and in supporting the growth of associated grasses, the influence of phosphate supply on legume nitrogen accumulation, the effect of nitrogenous fertilisers on legume development in pure culture and in grass-legume mixtures, and the question of associated growth between grasses and legumes.

## PROPOSED AGRICULTURAL AND PASTORAL RESEARCH INSTITUTE, WESTERN AUSTRALIA.

A proposal to establish in Western Australia an institute for agricultural and pastoral research has been under consideration since 1933. At a conference held last November, representative of the State Committee of the C.S.I.R., the Pastoralists' Association, and the Royal Agricultural Society, it was decided unanimously that the State committee should act as a consultative council for agricultural and pastoral research in Western Australia. It is proposed that the institute should be located at the University.

Since the initiation of the movement in 1933, much discussion has taken place, and at a sub-committee meeting held in April, 1935, the following resolutions were passed:—

That efforts be made to form a research institute, to be called the Agricultural and Pastoral Research Institute of Western Australia.

Objects: To encourage, organise, and conduct research in industry, and to co-operate with other bodies in the conduct of research.

Membership of the institute to be confined to research organisations concerned with the application of research to industry.

Management to be by a council of 12, 8 to be members of the C.S.I.R. State Committee (representing research organisations), these to co-opt four representatives of industry.

At the next meeting of the sub-committee on May 22, 1935, consideration of the constitution of the institute was deferred pending the arrival from England of Professor J. E. Nichols. In November last, Professor Nichols submitted a report to the State Committee of the C.S.I.R. on wool and pasture problems in the Eastern Goldfields and the North-west, embodying conclusions and suggestions for research.

## HAWKESBURY AGRICULTURAL COLLEGE.

In an address to the Millions Club at Sydney in November last, on the subject of "Hawkesbury Agricultural College and Agricultural Development," Principal E. A. Southee, O.B.E., emphasised the need for a wider appreciation of the value of agricultural education in the development of Australia's agriculture. Speaking particularly of the Hawkesbury College, which was established in 1891, Mr. Southee said: "While one is fully sensible to the fact that there are many aspects of successful farming which cannot be taught in an academic sense and can only be acquired by commercial experience, it is maintained that the experience can be enriched by a scientific grasp of the principles underlying all the operations of the farm and that the essential experience will bear good fruit much earlier than would otherwise be possible. If the College cannot mould experienced farmers it can inculcate a proper sense of values, foster a keen sense of observation, develop a reasoning, clear-thinking mind, capable of interpreting problems which arise; an understanding of the nature of the problem is half the battle. The College believes that every man ought to be bigger than his business, and the graduate of the College should carry away a body of systematic and digested knowledge which he can readily apply. While instruction in the basic principles and fundamentals involved in agriculture, as far as they are known, is stressed, it is realised that the technique of farming must hold a most prominent position, and the College farm of 3,500 acres is considered a big outdoor laboratory. Over 3,600 students have passed through the College and it is known that about 80 per cent. of these are engaged in some form of agriculture. Graduates of the institution include not only successful farmers throughout Australia, but also holders of official positions in all parts of the world. In recent years three Directors of Agriculture, three Directors of Dairying, a Commissioner of the Rural Bank, a Land Board Chairman, and the Commonwealth Supervisor of Dairy Exports have been Old Boys. The agricultural field staff and the dairy instructional staff of the N.S.W. Department of Agriculture—men who have gained the confidence of the farmers—are composed almost entirely of Old Boys. College graduates hold executive positions in all the farmers' and graziers' associations, the agricultural bureau, show societies, cattle societies and other bodies of a similar nature. The dairying industry in particular has absorbed graduates of Hawkesbury College which has in the last seven years sent approximately 50 per cent. of its 70 graduates to take up positions in other States where they have achieved signal success."

## FACILITIES FOR RESEARCH DEGREES AT ROTHAMSTED, ENG.

A recent circular letter from the Director of the Rothamsted Experimental Station draws attention to the facilities offered by the Station for research in agricultural science and also the arrangements by which temporary workers at the institution may become candidates for the research degrees of Cambridge and London Universities. The Station does not investigate problems outside the study of soil and the growing plant in health and disease; e.g., no work is done on plant breeding, animal nutrition, agricultural economics, etc. The permanent scientific staff numbers about 50, exclusive of post-graduate workers and scholarship holders. No fees are charged to voluntary workers for supervision of their work. Owing, however, to the high cost of apparatus, chemicals and other materials a charge is made (£25-£40 per annum according to the department of work) either to the worker or to the authorities sending him to the Station. Intending workers are requested to communicate in the first instance with the Assistant Director, stating the department in which they wish to work, and the proposed length of stay.

In certain circumstances a candidate for the Ph.D. (Cambridge) can carry out part of his work at Rothamsted under the direction of a supervisor appointed by the University; in certain circumstances one of the staff at Rothamsted may be appointed to act as supervisor while the candidate is working there.

It is also pointed out that research workers may submit work done at Rothamsted for the M.Sc., Ph.D., and D.Sc. degrees in the University of London. Except for the D.Sc. degree, the work must be done under the supervision of recognised teachers of the University. The Station's Director and Heads of Departments are recognised teachers.

### S.U. AGRICULTURAL GRADUATES' ASSOCIATION.

At the annual meeting of the Sydney University Agricultural Graduates' Association, held at Science House on February 21, it was resolved:

1. That steps be taken forthwith to give effect to the resolution carried at a meeting of the Association held on June 28, 1935, viz., that the S.U.A.G.A. be disbanded.

2. That this meeting decide to form forthwith a new organisation representative of graduates of the Faculty of Agriculture, Sydney University.

3. That a sub-committee be appointed to draft a constitution for submission to a subsequent meeting of graduates of the Faculty of Agriculture to be convened before the end of April, 1936.

The personnel of the sub-committee is as follows: Professor R. D. Watt, Messrs. J. G. Churchward (convenor), R. H. Anderson, T. H. Harrison, A. R. Woodhill, C. J. Magee, and J. M. Vincent.

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## Personal Notes

### CANBERRA, F.C.T.

Dr. A. J. Nicholson, Acting Chief of the Division of Economic Entomology, visited Western Australia during August and September, 1935, to study Lucerne flea, red-legged earth mites, and other pests of pastures. During November, he visited Tasmania to study insect problems of pastures there.

Dr. H. R. Angell and Mr. A. V. Hill, of the Division of Plant Industry, visited South Australia and Victoria in November and examined successful experiments for control of blue mould in tobacco seedlings by means of benzol in seed frames.

Mr. H. F. Smith left Canberra in October to study biometrics as applied to genetic problems, at London University, under Professor R. A. Fisher.

Dr. J. G. Bald, who worked at Cambridge for two years on virus diseases of plants, has returned to Canberra where he will investigate virus diseases of potatoes.

Mr. R. V. Fyfe returned to Canberra in December from Fiji where he had been carrying out experiments with the Lantana bug, *Teleonemia lantanae*.

Mr. A. L. Tonnoir returned to Canberra in November after touring Europe on holiday and on duty. He represented the Commonwealth at the Imperial Conference of Entomology in London, and also attended the meeting of the International Conference of Entomologists at Madrid.

## NEW SOUTH WALES.

Miss Lorna Byrne, Organiser of the Women's Section of the Agricultural Bureau of N.S.W., has been awarded a visitor's grant by the Carnegie Corporation, and will study developments in rural adult education in Great Britain, Ireland, and Scandinavia. Miss Byrne will return by way of Canada and U.S.A.

Mr. W. B. Gurney, State Entomologist, who spent 8½ months in Ceylon, India, Kenya and Uganda in search of parasites of fruit flies and of white-wax scale insects, returned to Sydney early in January.

Mr. D. T. Hartigan, who recently graduated B.Sc.Agr. (Sydney), has been appointed to the technical staff of Tooth and Co., Ltd., brewers.

Mr. W. Poggendorf returned in January from his trip to U.S.A. in connection with rice problems.

Mr. L. S. Cayzer, who was abroad for almost two years as Farrer Research Scholar, resumed duties in the State Department last month. He studied at Minnesota and Winnipeg, and secured his M.Sc. degree whilst abroad.

## VICTORIA.

Mr. J. L. Gillespie, B.Agr.Sc., who was for several years with H. V. McKay Massey Harris Pty. Ltd., has been appointed Secretary to the Melbourne University Appointments Board.

Mr. A. H. Bishop has joined the staff of the Shell Co. of Australia.

Mr. J. S. Ballantyne has been appointed Research Assistant to Professor Wadham.

Miss Stephanie Clark, who spent a year working on soil bacteriology at the University, has been appointed to a position in the C.S.I.R. and is working at the Veterinary Research Institute.

Miss Jean Robertson, who has completed two years' research on weeds and weed seeds, left for England at the end of February.

Mr. J. G. Baldwin has been appointed Junior Research Officer in the Soils Division of the C.S.I.R.

Mr. A. D. Meares, who returned from abroad at the beginning of last year, has now turned his attention to medicine.

Mr. F. M. Read, Chief Inspector of Horticulture in the State Department, has been appointed one of the Government nominees on the Victorian Dried Fruits Board, *vice* Mr. E. E. Meeking.

Dr. O. H. Frankel, of the New Zealand Wheat Research Institute, visited the State Research Farm, Werribee, recently on his return from a world survey of plant breeding stations. Other visitors to Victoria included Professor Prescott, Mr. D. B. Adam, and Mr. J. Barrett.

Interesting letters have been received from Mr. H. C. Forster in America where he is attached to the Statistical Department of the State College of Agriculture, Ames, Iowa. He tells of his attendance at the annual meeting of the American Society of Agronomy which was held in Chicago during December, and further states: "To an Australian the Americans appear to have a one-crop mind and that crop is maize. The whole aim of American agriculture in the recent adjustment programmes has been to attempt to include or improve the outlying States so that they may be grouped in the Corn Belt."

## SOUTH AUSTRALIA.

Mr. H. C. Gurney, who has been engaged on investigations of the effect of nitrogenous fertilisers on cereal crops at the Waite Institute since 1932, has been appointed to the staff of the Stuart Memorial College, Isfahan, Persia.

The Council of the University of Adelaide recently approved the inception of work on certain phases of nitrogen metabolism in tobacco, to be carried out at the Waite Institute by Dr. A. H. K. Petrie, in co-operation with the C.S.I.R. Miss R. Watson, B.Sc., and Miss D. Claridge, B.Sc. (Hons.), have been appointed to assist in these investigations, and commenced work under Dr. Petrie in December, 1935.

Messrs. J. K. Taylor and P. D. Hooper have returned to the Waite Institute after spending five months in the Murrumbidgee Irrigation areas, principally at Leeton and Griffith, in connection with a soil survey of the horticultural settlements.

Messrs. J. G. Baldwin, B.Agr.Sc., B.Sc., and G. D. Hubble, B.Agr.Sc., have been appointed Junior Research Officers of the Soils Division of the C.S.I.R., and recently commenced work at the Waite Institute.

Lord Barnby, a partner of Francis Willey & Co., wool merchants, Bradford, who was Controller of Wool Supplies for the British Government during the Great War, and is a member of the Council of the Wool Research Association at Torridon, Leeds, visited the Waite Institute in January.

## QUEENSLAND.

Professor E. J. Goddard, Dean of the Faculty of Agriculture in the University of Queensland, has been seconded to the Department of Agriculture and Stock as a part time officer for one year to formulate a scheme for co-ordinating the various research activities of the Department. Professor Goddard took up his new duties in January.

The Director of Tropical Agriculture in Queensland, Mr. C. J. McKeon, together with Dr. L. J. Miles, Plant Breeder, Mr. W. J. Cartmill, Chemist, and other members of the staff, took up residence at the newly-established Tropical Research Station at South Johnstone, North Queensland, at the beginning of December.

Mr. A. B. Cashmore, of the Noxious Weeds Section, C.S.I.R., spent several weeks in Queensland during December and January studying weed pest problems in the southern and south-western districts of this State. He also studied pasture weeds in N.S.W. during his extended absence from Canberra.

## WESTERN AUSTRALIA.

Mr. J. H. Riches recently resumed duties at the Muresk Agricultural College following two years' study of animal nutrition problems at the Rowett Research Institute.

Mr. S. G. Gray, an officer of the C.S.I.R., left for Canberra during December after spending several months at the Merredin Experiment Farm, in charge of the Commonwealth's cereal investigation work at that centre.

## TASMANIA.

Mr. W. M. Carne, F.L.S., Senior Plant Pathologist, C.S.I.R., who has in recent years been investigating various types of disorders which affect apples in storage, left Hobart by the Ormonde on February 1st for England to continue these investigations. It is expected that he will be absent for twelve to eighteen months. He was accompanied by Mrs. Carne and family.

Mr. F. H. Johnstone, B.Sc., formerly Chemist in the Department of Agriculture, has transferred to the Health Department as Analyst.